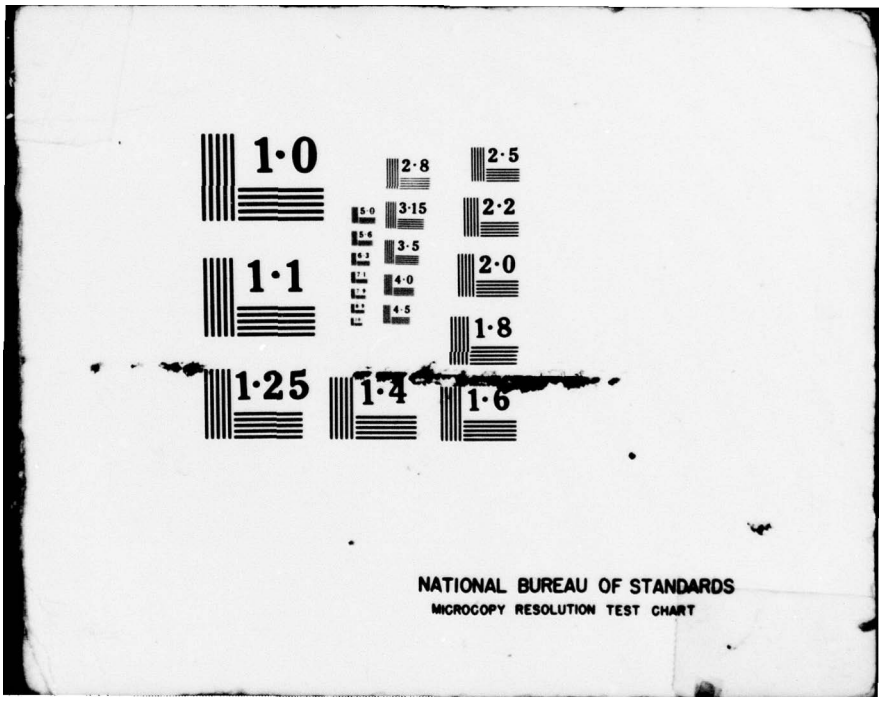
AD-A068 200 PUBLIC RESEARCH INST ARLINGTON VA F/G 5/3
AN ALTERNATIVE EXPLANATION OF THE CYCLICAL PATTERN OF QUITS.(U)
NOV 78 L JACOBSON

UNCLASSIFIED PRI-PP-233 NL

| OF |
ADA
068200

END
DATE FILMED
6-79
DDC


1·0
1·1
1·25
1·4
1·6
1·8
2·0
2·2
2·5
2·8
3·15
3·5
4·0
4·5
5·0
NATIONAL BUREAU OF STANDARDS
MICROCOPY RESOLUTION TEST CHART

PP 233

(2) LEVEL II

AD A068200

DDC FILE COPY

An Alternative Explanation of The Cyclical Pattern of Quits

Louis Jacobson

PUBLIC RESEARCH INSTITUTE
a division of the Center for Naval Analyses

INDEX TO PRI PUBLICATIONS

73-1 *The Retail Price of Heroin: Estimation and Applications*, George Brown, and Lester Silverman; May 1973.
73-2 *The Use of Longitudinal Data to Assess the Impact of Manpower Training on Earnings*, Louis Jacobson; July 1973.
73-3 *The Determinants of Daily Emergency Admissions to Hospitals* Lester Silverman; July 1973.
74-1 *The Effect of Unemployment Insurance and Eligibility Enforcement on Unemployment*, Arlene Holen, and Stanley Horowitz; April 1974.
74-2 *Undiagnosed Bacterial Meningitis in Vermont Children*, Lester Silverman, et al.; October 1974.
75-1 *Urban Crime and Heroin Availability*, Lester Silverman, Nancy Spruill, and Daniel Levine; April 1975.
75-2 *Removing Restrictions on Imports of Steel*, James Jondrow, Eugene Devine, Louis Jacobson, Arnold Katz, David O'Neill; May 1975.
75-3 *Abolishing the District of Columbia Motorcycle Squad*, Abram N. Shulsky; April 1975.
75-4 *Public Drug Treatment and Addict Crime*, Peter Stoloff, Daniel B. Levine, Nancy Spruill; October 1975.
75-5 *Unemployment Insurance Taxes and Labor Turnover: Summary of Theoretical Findings*, Frank Brechling; December 1975.

40-74 *Summary of Statement and Remarks at the Conference on Study of the Unemployment Insurance System, Arlington, Virginia, January 25, 1974*, April 1974.
112-74 *Unemployment Insurancy and Eligibility Enforcement*, Stanley Horowitz, and Arlene Holen; December 1974.
130-75 *Effects of the 1974 UI Extensions on Unemployment*, David M. O'Neill, Kathleen P. Classen, and Arlene Holen; December 1974.
173-75 *The Incentive Effects of the U.S. Unemployment Insurance Tax*, Frank Brechling; June 1975.
184-75 *An Evaluation of Proposed Alternatives for Increasing UI Tax Revenues*, Christopher Jehn; May 1975.
186-75 *The Effects of Unemployment Insurance on the Duration of Unemployment and Job Search*, Kathleen P. Classen; June 1973.
196-75 *Report of the Ocean Policy Research Workshop*, Robert L. Friedheim, Judith T. Kildow; February 1975.
197-75 *Earnings Losses of Workers Displaced from the Steel Industry by Imports of Steel*, Louis Jacobson; August 1975.
199-75 *Alternative Data Sources for Analysis of Unemployment Insurance*, Louis Jacobson; July 1975.
211-75 *The Effect of Unemployment Insurance on the Duration of Unemployment and Subsequent Earnings*, Kathleen Classen; September 1975.
239-75 *Discrimination Against Handicapped Persons: The Costs, Benefits and Inflationary Impact of Implementing Section 504 of the Rehabilitation Act of 1973 Covering Recipients of HEW Financial Assistance*, Dave O'Neill; February 1976.
260-76 *The Effects of Effluent Discharge Limitations on Foreign Trade in Selected Industries*, James Jondrow, David Chase, Christopher Gamble, Nancy Spruill; February 1976.
262-76 *Reducing the Burden of Federal Reporting: A Proposal*, Paul Feldman; February 1976.
264-76 *The Labor Market Effects of Unemployment Insurance: Summary of Findings*, Christopher Jehn; March 1976.
279-76 *The Measurement and Prediction of Reporting Costs*, David E. Chase and Daniel B. Levine; May 1976.
312-76 *Voucher Funding of Training: A Study of the G.I. Bill*, David O'Neill and Sue Goetz Ross; October 1976.

CRC-308 *An Evaluation of the GNP Deflator as a Basis for Adjusting the Allowable Price of Crude Oil*, James M. Jondrow and David E. Chase, February 1977.
CRC-313 *Losses to Workers Displaced by Plant Closure or Layoff: A Survey of the Literature*, Arlene Holen, November 1976.
CRC-315 *Shipyard Worker Employment and Turnover*, 2 Volumes, Louis S. Jacobson, November 1976.
CRC-324 *To Satisfy Demand: A Study Plan For Public Library Service in Baltimore County*, Vernon E. Palmour and Marcia C. Bellassai, June 1977.
CRC-349 *The Unemployment Insurance Tax and Labor Turnover: An Empirical Analysis*, Frank Brechling and Christopher Jehn, April 1978.
CRC-351 *Arizona Employment and Unemployment Data Code Book*, Louis Jacobson and Kathleen Classen, February 1978.
CRC-353 *The Tax Base of the U.S. Unemployment Insurance Tax: An Empirical Analysis*, Frank Brechling, April 1978.
CRC-354 *Pennsylvania Continuous Wage and Benefit History Codebook*, Kathleen Classen and Louis Jacobson, March 1978.

PP 165 *Effects of Trade Restrictions on Imports of Steel*, James M. Jondrow, November 1976.
PP 166 *Why It's Difficult to Change Regulation* Paul Feldman, October 1976.
PP 169 *Earnings Losses of Workers Displaced from Manufacturing Industries*, Louis S. Jacobson, November 1976.
PP 170 *A Time Series Analysis of Labor Turnover*, Frank P. Brechling, December 1976.
PP 172 *Unemployment Insurance and the Length of Unemployment*, Kathleen P. Classen, December 1976.
PP 175 *Public Drug Treatment and Addict Crime*, D. B. Levine, N. Spruill, and P. H. Stoloff, March 1977.
PP 192 *Effects of Unemployment Insurance Entitlement on Duration and Job Search Outcome*, Arlene Holen, August 1977.
PP 193 *A Model of Unemployment Insurance and the Work Test*, Stanley A. Horowitz, August 1977.
PP 194 *The Effect of Unemployment Insurance on the Duration of Unemployment and Subsequent Earnings*, Kathleen P. Classen, August 1977.
PP 195 *Unemployment Insurance Taxes and Labor Turnover: Summary of Theoretical Findings*, Frank Brechling, August 1977.
PP 198 *The Distributional Effects of Unemployment Insurance*, Kathleen P. Classen, September 1977.
PP 202 *Why Regulation Doesn't Work*, Paul Feldman, September 1977.
PP 203 *Efficiency, Distribution, and the Role of Government in a Market Economy*, Paul Feldman, September 1977.
PP 232 *Can Policy Changes Be Made Acceptable to Labor?* Louis S. Jacobson; August 1978.
PP 233 *An Alternative Explanation of the Cyclical Pattern of Quits,"* Louis S. Jacobson; October 1978.
PP 234 *Does Federal Expenditure Displace State and Local Expenditure: The Case of Construction Grants?* James Jondrow and Robert A. Levy; October 1978.
PP 238 *Unemployment Insurance and The Unemployment Rate,"* Kathleen Classen Utgoff; October 1978 .

(14) PRI-PP-233

(6) AN ALTERNATIVE EXPLANATION OF THE CYCLICAL PATTERN OF QUITS

(10) Louis Jacobson

(9) Professional Paper, No. 233

(11) November 1978

(12) 25 p.

CENTER FOR NAVAL ANALYSES
1401 Wilson Boulevard
Arlington, Virginia 22209

AN ALTERNATIVE EXPLANATION OF THE CYCLICAL PATTERN OF QUITS

by

Louis Jacobson

INTRODUCTION

Time series studies uniformly have found that aggregate quit rates in manufacturing industries are strongly related to business conditions, [6]. Quits are high during periods of low unemployment and vice-versa. The model of economic behavior most often used to explain these results is one of individual utility (or income) maximization, [e.g. 7], workers are assumed to quit jobs in response to changes in the expected value of job search. Implicit in these studies is the idea that changes in aggregate quit rates over the business cycle are caused by changes in the probability that individuals will quit.

This paper presents evidence that, at least for the steel industry, a change in the probability that individuals will quit is not the major reason why aggregate quit rates are cyclically sensitive. The alternative explanation, tested in this study, is that changing quit rates is an aggregation phenomenon traceable to changes in the tenure distribution of the employed work force.

The author wishes to thank his colleagues at the Center for Naval Analyses, particularly Paul Feldman, Frank Brechling, and Kathleen Classen Utgoff for numerous helpful suggestions.

This explanation is not totally new. In a 1958 article on "industrial feudalism", Ross [8] pointed out that employment growth in manufacturing had fallen since the 1920s, reducing the proportion of young, low-tenure workers in the labor force. He suggested that since these workers are the ones most likely to quit, it was to be expected that the quit rate would also have fallen.

The same argument is used here to explain variations in quit rates over the business cycle. Short-run cyclical fluctuations also change the characteristics of the employed labor force. In a cyclical downturn, hiring stops and low-tenured workers are laid off. In an upswing, new hires rise and low-tenured workers are recalled, substantially increasing the *number of young, low-tenured workers employed.* The central hypothesis of this paper is that it is the short-run fluctuation in the fraction of workers with very high quit probabilities that affects the aggregate quit rate, not only fluctuation in the rate at which particular workers quit.

METHODOLOGY

The formal representation of aggregate attrition is presented in equation 1:

$$(1) \quad a = \int_{t=0}^{t\ max} q(t,\bar{X}),f(t)dt$$

where

a = the aggregate attrition rate

$q(t,X)$ = the probability that a worker will leave the industry in the absence of any action by his employer to reduce total employment

t = tenure

$\overline{X}$ = a vector of economic variables such as the general unemployment rate

$f(t)$ = the tenure distribution measured in percent of the total work force

The aggregate attrition rate varies with differences in tenure and economic conditions. I will adopt, as a working hypothesis, the polar case in which economic variables ($\overline{X}$) have no effect on the probability that an individual worker will leave voluntarily; only cyclical changes in the tenure structure affect the probability. I will test the hypothesis by examining how well variations in the tenure structure account for observed behavior.

Changes in the tenure distribution of the employed work force, and quit rates in discrete tenure groups, are not recorded in standard data published by BLS. To measure the tenure of individual workers, we use data from the Social Security Administration's Longitudinal Employer Employee Data (LEED) file a data set that records employment and earnings for a sample of

individual workers over the period 1957 - 1972.* Unfortunately, while allowing tenure to be measured, and recording labor market movements of workers in the sample, the LEED file does not include identifiers of labor turnover categories such as quits, new hires, layoffs, or rehires. Thus to use these data to demonstrate that changes in the aggregate quit rate can be explained by changes in the tenure distribution requires a number of steps: First, the probability that a worker with given tenure will leave the steel industry due to attrition (voluntary separation in the absence of an employment reduction) must be measured. Second, the tenure distribution of workers in the steel industry is measured in two periods during which employment fell. Third, the aggregate attrition rate for each period is calculated by multiplying the measured attrition probability for each tenure group by the fraction of the workforce in that tenure group and summing across all tenure groups. Fourth, the aggregate attrition rate is adjusted to correspond to the BLS measure of quits and other separations, and finally, the two measures are compared.

*These data provide the age, race, and sex of 1% of the covered workforce. Quarterly earnings, industry, and location is also reported for each employer for whom the individual worked during 1957 - 1972. (See [9] for more detailed information.) With these data the tenure of each worker in an industry since 1957 is calculated by counting the number of quarters since 1957 in which the worker shows any employment in that industry. (For workers first hired prior to 1957, age is used as a proxy for tenure.) Separations in a given year are tabulated by counting the number of workers for which an employer report is found for the given industry in the given year, but no report for that industry is found subsequently.

Measuring Attrition

Attrition in a given tenure group is measured by counting the fraction of workers in that group who permanently left the industry in a year when few if any permanent separations were due to layoff. The year chosen for this purpose was 1964, a year in which employment in the industry grew by 5.2%. Equation 2 shows the attrition probability

$$q(t) = \frac{S_t}{N_t} \qquad (2)$$

where

$q(t)$ = probability that workers with tenure (t) will leave due to attrition

S_t = number of workers with tenure (t) who permanently separated in 1964

N_t = number of workers with tenure (t) who were employed in the steel industry at any time in 1964

Table 1 shows the number of workers and number of separations by tenure group for 1964 as well as the attrition rate for each tenure group. The latter figures illustrate the strong negative association between tenure and the probability of leaving due to attrition. Workers with less than fours years' tenure are about ten times more likely to leave due to attrition than higher tenure workers. These figures also show how important the fraction of low tenure workers is as a determinant of aggregate attrition. Workers with less than four years' tenure

TABLE 1

ATTRITION PROBABILITIES BY TENURE IN 1964

Tenure (years)	Number of permanent separations 1964 (S)	Number of workers employed during 1964 (N)	Attrition (S/N)
Less than 1	215	767	.280
1	37	207	.179
2	10	96	.104
3	13	106	.123
4-9	11	195	.056
10-24	49	1781	.028
25-39	45	2089	.022
40-44	13	424	.031
Greater than 44	64	220	.291
Total	457	5885	.078

Note: For groups including workers with more than three years' tenure, age is used as a proxy for tenure. The assumption is that all workers are hired at age 20. Thus, workers with greater than 44 years' tenure are workers at least 63 years old (with at least three years' experience).

made up only 20% of the labor force. Yet this group accounted for 60% of all attrition.

Tenure Distribution

Table 2 shows the tenure distribution of the work force in 1960, 62 and 64. The extent to which the tenure distribution is affected by business conditions is evident in this table. In 1964, a year of unusually rapid growth, 13% of the labor force had less than one year tenure. In 1960 and 1962, years of sizeable decline, the proportion of workers with less than one year tenure was very low. These distributions reflect the residue of past trends in employment. For example, employment rose rapidly in early 1959 in anticipation of the strike which occurred July-October 1959. This accounts for the high proportion of workers in 1960 with one year of tenure. Since many of them also remained in the industry, a high proportion of the work force in 1962 had three years' tenure.

Estimated Aggregate Attrition

Tenure-specific attrition probabilities calculated from 1964 data are assumed to be invariant over time. Applying these probabilities to the 1960 and 1962 tenure distributions allows estimation of aggregate attrition in 1962 and 1960, as described in equation 1. The aggregate attrition rates for 1964, 1962, and 1960 are displayed in table 3, together with the net employment change in each year. As expected, aggregate attrition in 1960 and 1962 is considerably less than attrition in 1964.

TABLE 2

TENURE DISTRIBUTION 1960, 1962 AND 1964

	Proportion of Workforce Tenure t in:		
Tenure (years)	1964	1962	1960
Less than 1	13.0	3.8	3.5
1	3.5	2.5	7.9
2	1.6	1.7	1.6
3	1.8	6.3	*
4-9	3.3	4.3	7.1
10-24	30.3	33.2	34.7
25-39	35.5	35.9	33.0
40-44	7.2	7.6	6.6
Greater than 44	3.7	4.8	5.6

*Tenure of three years could not be measured in 1960 because 1957 was first year new hires could be observed.

TABLE 3

NET EMPLOYMENT AND ESTIMATED AGGREGATE ATTRITION RATES IN THE STEEL INDUSTRY

	1964	1962	1960
Net employment change	5.2	-4.9	-9.4
Aggregate attrition rate	7.8	6.0	6.3

Adjusting Attrition to Match BLS Turnover Data

To determine if changes in tenure distribution can explain changes in the aggregate quit rate, we compare the attrition measures shown above to voluntary turnover as measured by BLS. Attrition resembles what BLS calls "quits and other separations" (QOS). These measures are not exactly the same, however. Attrition measures only permanent separations not designed to reduce employment. Thus, QOSs, which include transfers and unexcused temporary absences of over 7 days, are likely to be considerably greater than attrition.* To avoid confusion due to the difference in levels, we assume that the mix between permanent and temporary separations is not cyclically sensitive. Under this assumption, it is possible to compare percentage changes in the two measures.

*Attrition excludes interfirm job change within the steel industry as well. In the steel industry, however, interfirm intraindustry transfers are exceedingly rare.

A second difference is that QOSs include only workers who were employed when they separated, while attrition includes workers who severed their attachment to the industry during the year, regardless of whether they were employed when they left. We assume that the propensity to leave voluntarily is independent of whether the worker is employed or on temporary layoff.*

To take account of this difference, the attrition measures in table 3 were recalculated to reflect the probability of leaving due to attrition only while employed.**

Table 4 shows the QOS rate and the calculated attrition rate.

Comparison of Attrition and Quits

The adjustment increases the attrition rate in 1964 by 10.2% and reduces it by 7.1% and 12.4% in 1962 and 1960 respectively. Even after the adjustment, the attrition rate is about 45% of the QOS rate. This suggests that about 55% of QOSs

*This assumption produces conservative estimates. The propensity to leave permanently while on layoff is probably greater than the propensity to leave while employed. Laid off workers have more time to explore alternatives. In addition, a worker who intends to leave has an incentive to delay leaving voluntarily if he anticipates being laid off. Unemployment insurance is available immediately to workers laid off but quits must wait for 6-8 weeks.

**The procedure used is based on computation of the number of man-years of employment (as opposed to the number of men employed in a year) in each tenure group. The details of the computation are shown in the appendix.

eventually return to the steel industry. Table 5 compares the QOS rate and the attrition rate in 1962 and 1960 respectively.

TABLE 4

TURNOVER RATES
(Percentage of annual employment)

	1964	1962	1960
BLS Measures			
Quits	7.2	3.6	3.6
Other separations	8.4	7.2	6.0
QOS	15.6	10.8	9.6
LEED Measures			
Attrition	7.8	6.0	6.3
Adjusted attrition (attrition while employed)	8.6	5.6	5.6

TABLE 5

QOS AND ATTRITIONS COMPARED

	1962	1960
QOS rate as % of 1964 QOS rate	69.2	61.5
Attrition rate as % of 1964 attrition rate	65.1	65.1
% of QOS rate explained by attrition	94.5	106.3

When voluntary turnover is calculated by applying tenure specific attrition rates to observed tenure profiles, we predict less voluntary turnover than predicted by adjusted BLS statistics in 1962 and more than indicated in 1960. This could be due to the quit propensity being higher in 1962 and lower in 1960 when compared to the 1964 rate. It could also be that the divergence between the predicted and actual values is due to sampling variability rather than difference in attrition probabilities. At least in the steel industry, most, if not all, of the variability of voluntary turnover can be explained by some changes in the tenure structure.

THEORETICAL IMPLICATIONS

One theory of job search, typified by Alchian [1,2] assumes that an employed worker has better information about his own job than about the job market in general. When aggregate demand falls and his hours or wages are reduced, the worker perceives that his own earnings have fallen but not that earnings have fallen elsewhere, and quits to search for a higher paying or steadier job. Thus, this theory predicts an increase in individual quit probabilities during a recession [4].

Observations that the aggregate quit rate <u>falls</u> in a recession have been taken as contradicting this proposition. This paper has shown that the evidence need not be viewed as contradicting the theory; cyclical changes in the tenure structure of the employed work force, due to both permanent displacement and

temporary layoff, can cause large fluctuations in the aggregate quit rate, independently of changes in the probability that a given worker will quit. In fact, changes in the tenure structure can so dominate the aggregate quit rate that quit probabilities at the individual level are not discernable in aggregate data.

An alternative assumption of job search theory is that attrition probabilities will increase when aggregate demand rises because opportunity to improve ones job will increase. But, again, this paper has shown that attrition probabilities do not necessarily change with variation in business conditions. It may be that the expected value of a job offer is more strongly affected by the relatively stable characteristics of the worker and of the job itself than by the cyclical changes in opportunity or wages. This is particularly likely to be true if evaluation of job characteristics by on-the-job experience is necessary to determine the expected value of a job. A worker may find that, despite an excellent wage package, the job itself is onerous or he is unlikely to be promoted because he, in one way or another, does not fit in.

The empirical findings about attrition and tenure are applicable to job search theory in another way. In Mortensen's model of search by a worker who is already employed [5], the probability of finding relatively unattractive aspects of the current job is high early in a worker's career, and falls

exponentially with tenure. Consequently, attrition rates tend to decline with tenure. The attrition-tenure relation measured in this work strongly supports this prediction.

EXTENSION OF FINDING TO OTHER INDUSTRIES

A single swallow does not make a summer, and a demonstration that cyclical changes in the tenure structure in the steel industry can explain observed changes in the aggregate quit rate does not prove that quit probabilities at the individual level are stable over the cycle. It is important to consider whether results based on steel industry data are applicable to manufacturing in general.

There are three reasons why steel might be a bad example:

First, the rapid fall in the attrition propensity with increasing tenure may be peculiar to the steel industry. If so, the "elasticity" of quits with respect to tenure changes would be unusually high.

Second, cyclical swings in quits may be relatively small in steel. Even if the attrition-tenure relation in other industries was similar to that in steel, far greater fluctuations in the tenure structure of other industries would have to occur in order to account for observed changes in quits.

Third, cyclical fluctuations in layoffs could be considerably greater in steel. This would make it comparatively easier for quits to be counted as layoffs.

Limited information about the relation between attrition probabilities and tenure in a broad range of manufacturing industries was generated as part of another study [3].* The same general pattern was observed in each industry. A minor difference was that attrition among low tenure workers relative to high tenure workers in auto manufacturing and steel was somewhat higher than in other industries. The major difference, however, was that attrition was far lower for all tenure groups in steel and automobiles relative to similar groups in low-wage, low capital-labor-ratio industries, such as textiles.

The variability in the quit rate in steel is somewhat lower but not very different from that in all manufacturing on an absolute basis but it is relatively high on a proportional basis. During the 1960s, quits averaged 1.9% per month in manufacturing and .7% in steel, but the standard deviation of the aggregate quit rate was 1.8% in manufacturing, 1.3% in steel.

Layoffs and "other separations" were similar in steel and manufacturing as a whole. It is reasonable to conclude that changes in the age-tenure structure, together with quits that are counted as layoffs can account for much of the variation in the BLS quits in all industries.

*This study focused on earnings losses, not turnover, and limited the sample to workers age 23-53, with more than one year tenure, employed each year 1960-70.

REFERENCES

[1] Alchian, Armen A., "Information Costs, Pricing, and Resource Unemployment," in Microeconomic Foundations of Employment Inflation Theory, W.W. Norton & Co., 1970

[2] Alchian, Armen A., and Allen, William R. University Economics, Wadsworth Publishing Co., 1972

[3] Jacobson, Louis S., "Earnings Losses of Workers Displaced from Manufacturing Industries," in The Impact of International Trade and Investment on Employment, William Dewald, editor, GPO, forthcoming

[4] Lippman, S.A., and McCall, John J., "The Economics of Job Search: A Survey," Economic Inquiry, Vol. 13, Sept. 1976

[5] Mortensen, Dale T., "The Turnover Implications of Learning About Attributes on the Job, "Mimeo, Northwestern University, Department of Economics, Sept. 1975

[6] Parsons, Donald O., "Models of Labor Market Turnover: A Theoretic and Empirical Survey," in Research in Labor Economics, Ronald Ehrenberg, editor, Vol. 1, 1977, JAI Press, Greenwich, Conn.

[7] Pencavel, John H., "An Analysis of the Quit Rate in American Manufacturing Industries," Research Report Series No. 114, Industrial Relations Section, Department of Economics, Princeton University, Princeton, N.J., 1970

[8] Ross, Arthur M., "Do We Have a New Industrial Feudalism?," American Economic Review, 48, pp. 903-920 (Dec. 1958)

[9] Social Security Administration, Office of Research and Statistics, The 1% Sample - Longitudinal Employee-Employer Data File, Nov. 1971

[10] U.S. Department of Labor, Bureau of Labor Statistics, Employment and Earnings, United States, 1909-72 (BLS Bulletin 1312-9)

APPENDIX A

MEASUREMENT OF ATTRITION AMONG EMPLOYED WORKERS

The attrition rate defined in equation 1 on page 2 measures the fraction of workers employed in an industry at any time during the year who leave the industry permanently, in the absence of any attempt by employers to reduce employment. "Quits and other separations" (QOS), as measured by the BLS, is the number of employed workers who leave and are not laid off as a fraction of man-years of employment. This appendix presents a method of adjusting the attrition measure so that only workers who permanently leave while employed are counted. This adjusted attrition measure and the QOS measure will then be as comparable as possible.

Equation A-1 shows how the attrition rate was estimated initially:

$$(A\text{-}1) \qquad a = \frac{\sum A_t}{\sum N_t} = \frac{\sum q(t) \cdot N_t}{\sum N_t}$$

where

$$q(t) = \frac{S_t^{64}}{N_t^{64}}$$

a = the attrition rate

A_t = the number of workers who leave tenure group t due to attrition

N_t = the number of workers employed in tenure group t

$q(t)$ = the probability of a worker with tenure t leaving due to attrition

S_t = the number of workers who permanently leave tenure group t

To calculate the attrition rate of employed workers, the number of man-years of employment (L_t) must be substituted for the number of men employed (N_t) wherever it appears in equation A-1.

For workers employed prior to the start of a given year, the number of man-years of employment is defined in equation A-2:

$$L_t = N_t - d_S \cdot S_t - d_T \cdot T_t \quad \text{(for } t \text{ greater than equal to one year)}$$

where:

L = man-years of employment

N = the number of men employed during the year

S = the number that leave permanently

d_S = the average amount of time the leavers were not employed

T = the number that leave temporarily

d_T = the average amount of time the temporary leavers were not employed.

We assume that separations occur randomly throughout the year. Thus the average separatee is not employed for one-half year ($d_S = 1/2$). We assume that for every permanent layoff (D) five workers are temporarily laid off ($T = 5D$). (This estimate is based on the empirical finding that 85 percent of manufacturing workers laid off eventually are rehired.*) We also assume that every laid off worker is unemployed for one-fifth of a year ($d_T = 1/5$). (This estimate is derived from Pennsylvania's Unemployment Insurance Records for primary metal workers.) Substituting these values in equation (A-2) gives:

$$(A\text{-}3) \qquad L_t = N_t - (1/2) \cdot S_t - (1/5) \cdot 5D_t$$

The number of permanent layoffs (D) equals total separation (S) less attrition:

$$(A\text{-}4) \qquad D_t = S_t - A_t = S_t - \tilde{q}(t)L_t$$

where

$$\tilde{q}(t) = \frac{S_t^{64}}{L_t^{64}}$$

*See: Frank Brechling, "An Analysis of Labor Turnover," p 170, The Public Research Institute, Arlington, Virginia (Dec. 1976).

The resulting equation for man-years of employment for workers other than new hires (workers with greater than one year tenure) is:

$$(A\text{-}5) \qquad L_t = \frac{1}{1-\tilde{q}(t)} \cdot (N_t - (3/2)S_t)$$

For new hires, i.e., workers with less than one year tenure, the equation is more complicated. We assume that hires are evenly distributed throughout the year. Thus on average, each worker would be employed a half year. Each separation among these new hires then reduces man-years of employment by one-quarter year (not one-half year) and each temporary layoff reduces man-years of employment in the group by one-tenth year (not one-fifth year). The equation for new hires is thus:

$$(A\text{-}6) \qquad L_t = (1/2)\cdot N_t - (1/4)\cdot S_t - (1/10)\cdot 5D_t \quad \text{(for t less than one year)}$$

and, substituting for D as in equation (A-4)

$$(A\text{-}7) \qquad L_t = \frac{1}{1 - \frac{\tilde{q}}{2}}\left(\frac{N_t}{2} - \frac{5}{4} \cdot S_t\right)$$

The adjusted estimate of attrition is calculated as follows:

First, man-years of employment in each tenure group in 1964 (L_t^{1964}) are calculated using equations A-3 and A-6 and the data in table 1. (Permanent layoffs were assumed zero in 1964.) Using this value of (L), the adjusted attrition propensities ($\tilde{q}$) are then calculated. Man-years of employment in 1962 and 1960 can thus be calculated using equations A-5 and A-7 and the data in table 2. Given (L) the number of attritions from employed workers can be estimated by multiplying L by ($\tilde{q}$). The net adjusted attrition ratio is then calculated using equation A-1. The results of this calculation were reported earlier in table 5.

The accuracy of the procedure for estimating the number of man-days of employment (L) was checked by comparing the estimates to direct measure of men employed in primary metal industries, available from state Unemployment Insurance records in Pennsylvania. (Almost all of these workers were in the steel industry.) These data also provided a measure of the total fraction of each year unemployment insurance benefits were paid to these workers. Subtracting the number of man-years of employment from the number of men provides a reasonably accurate measure of man-years of employment. Table A-1 shows the ratio of man-years to men employed in 1960 and 1962 in Pennsylvania

and the nation as a whole.* The national statistic was derived from Social Security data and the procedures discussed in the main text.** The ratios are quite similar. A possible explanation for the relatively large difference in 1964 is that most of the divergence between L and N was due to permanent separation of new hires. Those workers may have found jobs relatively quickly and therefore weeks of unemployment greatly under-estimates weeks not employed in primary metals.

TABLE A-1

COMPARISON OF MAN-YEARS VERSUS MEN EMPLOYED

	Pennsylvania	U.S.
Man-years employed as a fraction of men employed (L/N)		
1964	98.6	96.1
1962	93.1	93.4

*Source for Pa. data - Continuous Wage and Benefit History of Workers Covered by Pennsylvania Unemployment Compensation Law, Benefit Experiences and Industry of Claimant, Report #2 1962, Report #4, 1964; Pa. Dept. of Labor and Industry, Bureau of Employment Security, Harrisonburg, Penna.

**New Hires were not measurable with UI data, thus L was significantly over-estimated in years with major employment growth. The measure of L using Social Security data was adjusted to take this into account.